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(54) Temperature indicating paint and method of preparing a specimen with the same

(57) A temperature indicating paint which is generally time independent comprises a pigment containing one or more of the following elements; silver, gold, platinum, palladium, copper, nickel, chromium, titanium and silicon, dispersed in between 10% and 70%, by weight, of solvent and resin. The paint is applied to a specimen by brushing or spraying and the specimen is then stoved for 5 minutes at between 750°C and 850°C.

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TEMPERATURE INDICATING PAINT AND METHOD OF PREPARING A SPECIMEN WITH THE SAME

This invention relates to temperature indicating paint and a method of preparing a specimen with the same.

Coatings which change colour or some other physical property at one or more known temperatures are a useful tool in the development of aero-engine components. Techniques which employ such thermal coatings have several advantages over other methods in that they are non-destructive, relatively low cost, and produce a temperature profile over the whole surface of a component, rather than just at discrete points as with thermocouples.

Temperature indicating paints, or thermal paints as they are also known, have shortcomings, one of which is that the colour/physical changes are, to a varying degree, time dependent and to a lesser extent pressure dependent. The usual technique to overcome this problem is to temperature calibrate all multi-change paints (which when subjected to a thermal gradient may reveal several permanent changes, each being assigned a temperature isotherm) at various times in the laboratory. However, temperature is not the only parameter affecting these changes as other environmental conditions may also play a part.

To overcome the time dependent nature of known thermal paints a datum coating can be applied to provide an isotherm on a component, under operating

conditions, which has been previously demonstrated to be time and environmentally independent. The mechanism involved in the change to form the isotherm should be a function of temperature, and irrespective of the operating gas environment so that a datum isotherm can be allocated to the component with confidence regardless of running time or operating conditions. Ideally, at least three datum markers covering a suitable temperature range should be used for internal calibration of a multi-change thermal paint.

Metal coatings have previously been used for internal datum markers utilising silver, gold and gold/silver alloy. Gold and silver have been applied by electro-plating and gold/silver alloy by flame spraying. However, with particular reference to aero-engine development with components such as turbine blades such coatings have been found unsatisfactory. The methods of application quoted above usually result in an average coating thickness of 25um to 30um for electro-plating and 50um to 75um for flame spraying. This amount of material has been known to cause problems when flowing in the molten state by blocking turbine blade cooling holes. These processes are also relatively costly and time consuming whilst requiring expensive equipment. When plating turbine blades with gold and silver it is difficult to adequately mask off the leading and trailing edge cooling holes prior to plating. These masking difficulties result in silver and gold plate missing from crucial areas and hence gaps will result in the data necessary to assess the blade

temperature profile. Furthermore, the surface of a flame sprayed coating is extremely rough, causing both contamination and interpretation problems.

It has now been found that the use of a precious metal coating applied as a paint overcomes most or all of the disadvantages mentioned above.

According to the invention a temperature indicating paint comprises a pigment containing one or more of the following elements; silver, gold, platinum, palladium, copper, nickel, chromium, titanium, and silicon; dispersed in between 10% and 70%, by weight, of solvent and resin.

According to another aspect of the invention a method of preparing a specimen with a temperature indicating paint comprises the step of applying a temperature indicating paint according to the invention to a specimen by brush or by spraying.

Preferably, the specimen is stoved for up to 5 minutes at a temperature between 750°C and 850°C.

The invention allows for a minimum coating thickness required to give a uniform coverage thereby reducing material costs and the problems encountered with flowing of excess molten metal. The method can be applied 'in house' using conventional techniques. Furthermore, elimination of masking around aerofoil cooling holes is no longer n cessary and the improved surfac finish over flame-sprayed silver/gold alloys allows the

paint to directly relate to the underlying substrate.

The invention will now be described by way of examples.

According to the invention a thermal paint based on silver is applied to a component such as a turbine blade.

The paint consists of 64.5% of a silver pigment and high temperature resin in the form of a paste, and 35.5% of Cellosolve Acetate (also known as 2-Ethoxyethyl Acetate) used as a solvent. Xylene can be used instead of Cellosolve Acetate. The ratio of solvent can vary between approximately 10 and 70%. This paint provides a medium thermal marker at $942 \pm 2^{\circ}C$. The silver paste is marketed by Johnson Mathey Chemicals for electrical capacitor and thermistor use under code number E112.

A high thermal marker paint utilises a silver/palladium paste to produce a marker at $1052 \pm 3^{\circ}C$. The paint consists of 67.6% of a 6:1 Ag/Pd paste, and 32.4% Cellosolve Acetate or Xylene. The ratio of silver to palladium can be varied to up to 50% palladium. However, a 6:1 Ag/Pd paste is commercially available from Englehard Ltd under the codename T13194. As above the ratio of solvent to paste can be anything from 10-70%.

A further paint having a transition temperatur of $977 \pm 2^{\circ}C$ consists of a silver/platinum paste in the ratio 20:1, also available from Englehard Ltd under

the code number T2786. The optimum ratio is 62.5% silver/platinum paste and 37.5% solvent. The ratio of silver to platinum may be varied to up to 30% platinum and, again, the ratio of paste to solvent may be varied to provide for between 10 and 70% solvent.

Other secondary elements such as gold (up to 99%), copper (up to 99%), silicone (up to 60%), titanium (up to 10%), chromium (up to 10%), and nickel (up to 2%) can be alloyed with silver to produce silver binary alloy pigmented paint systems.

After mixing with the solvent, the paint is sprayed or brushed on to the specimen. After air drying the specimen is stoved for 5 minutes at 750°C to 850°C to produce a specular finish. Stoving is required to bond the paint film to the substrate otherwise it has no toughness and can be easily damaged by handling. Exceptionally, stoving may be carried out at 300°C for one hour but this is not recommended to to the friable nature of the coating at this temperature.

A major advantage of thermal datum markers based on metallic alloys is the conductivity of the paint/coating matrix. Thus silver as a primary

alloy has the advantage of excellent conductivity whereas standard thermal paints are insulators. A major use for the paints are insulators. A major use for the paints described above is as single change paints in their own right as well as thermal datum markers. The metallic paint reveals a more representative picture of surface thermal

mechanisms, for instance the ability of a turbine blade to dissipate heat. Silver also has a convenient melting point of 960°C and is commercially available as well as having excellent conductivity. Gold, although having similar advantages to silver will diffuse into a nickel based alloy specimen.

It is recognised that the ideal thermal marker will be a eutectic alloy to ensure a rapid change from solidus to liquidus. However, commercially available eutectic alloys with melting points in the desired temperature ranges are practically impossible to obtain in the form required for paint manufacture. There is no eutectic mixture formed with silver/palladium and silver/gold alloy. In any case only a physical change observable by the human eye is necessary and these cases the first definite change from a specular finish achieved on stoving is all that is necessary to allocate an isotherm.

All percentages are by reference to weight in this specification.

CLAIMS

1. A temperature indicating paint comprising a pigment containing one or more of the following elements; silver, gold, platinum, palladium, copper, nickel, chromium, titanium, and silicon; dispersed in between 10% and 70%, by weight, of solvent and resin.

2. A temperature indicating paint according to claim 1 wherein the solvent is either 2-Ethoxyethyl Acetate or Xylene.

3. A temperature indicating paint according to claim 1 or claim 2 wherein the pigment contains silver.

4. A temperature indicating paint according to claim 3 wherein the paint contains 64.5% pigment and resin and 35.5% solvent, by weight.

5. A temperature indicating paint according to claim 1 or claim 2 wherein the pigment contains silver and palladium, and wherein the ratio of silver to palladium is up to 50% palladium, by weight.

6. A temperature indicating paint according to claim 5 wherein the silver to palladium ratio is 6:1 and the paint contains 67.6% pigment and resin and 32.4% solvent, by weight.

7. A temperature indicating paint according to claim 1 or claim 2 wherein the pigment contains silver and platinum, and wherein the ratio of silver to platinum is up to 30% platinum, by weight.

8. A temperature indicating paint according to claim 7 wherein the ratio of silver to platinum is 5% platinum, by weight, and the paint contains 62.5% and 37.5% solvent, by weight.

9. A method of preparing a specimen with a temperature indicating paint comprising the step of applying a temperature indicating paint according to any one of claims 1 to 8 to a specimen by brush or by spraying.

10. A method of preparing a specimen with a temperature indicating paint according to claim 9 further comprising the step of stoving the specimen for up to 5 minutes at a temperature between 750°C and 850°C.

11. A method of preparing a specimen with a temperature indicating paint according to claim 9 further comprising the step of stoving the specimen for up to 1 hour at 300°C.

12. A temperature indicating paint substantially as described herein with reference to the examples described above.

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